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Perceptions on greywater reuse for home gardening activities in two rural villages of Fetakgomo Local Municipality, South Africa

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ABSTRACT

Greywater reuse has been adopted worldwide as an alternative source to freshwater and has been found to contribute to the household food supply. In this study, we assess the greywater reuse for home gardening in two rural communities (Ga-Seroka and Ga-Nkwana) in Limpopo Province, South Africa, using a mixed methods approach (Qualitative and Quantitative). A total of 95 and 87 households were randomly selected in Ga-Seroka and Ga-Nkwana villages, respectively. Field surveys from the selected households were gathered using structured questionnaires and then analysed using statistical package software. The study showed that 66% of the respondents from Ga-Nkwana village reused their greywater for home gardening when compared to 59% from Ga-Seroka. Thirty-nine percent (39%) of Ga-Nkwana and 40% of Ga-Seroka respondents used this greywater for irrigating fruit trees, whereas 24% and 22% in Ga-Nkwana and Ga-Seroka villages, respectively, used it for irrigating vegetables that are not eaten raw. Many respondents (73% and 85%) in Ga-Nkwana and Ga-Seroka villages mentioned that, they were not aware of problems associated with greywater reuse, hence, they continue using it for home gardening. We, therefore, concluded that although greywater reuse for home garden irrigation is practised in the two communities, its utilization is still with caution.

1. Introduction

Water is a scarce resource and ensuring sustainable supply, especially in view of possible climate change impacts, has become a significant challenge globally (Lundqvist et al., 2005; Jenerette and Larsen, 2006; Abusam, 2008). Africa is one of the most vulnerable continents to climate change and variability, due to its high low adaptive capacity (IPCC, 2007; Epule et al., 2017). Vulnerability in Africa of is aggravated by climate change and variability, especially semi-arid and arid areas, which promotes strong winds and high evaporation rates, as well as low levels of economic development that hamper community adaptive capacity to the associated impacts (Bruckner, 2012). In addition, these arid like conditions are characterised with erratic rainfall patterns which impact negatively on the poor communities. For instance, climate trends show a gradual shift towards greater extremes in selected parts of southern Africa, which have increasingly become drier, and the wetter tropical areas witnessing intensified precipitation and flooding (Hulme et al., 2001). According to FAO (2016), on a continental scale, 86% of inventoried abstractions are used for agriculture, which is a value higher than the global agricultural water withdrawal (70%). South Africa is among the 14 African water-scarce countries, marked with high spatiotemporal rainfall variability (Earle, 2005). Average annual rainfall for South Africa is approximately 454 mm when compared to an overall global average of 860 mm (Earle, 2005). It is unpredictable and unreliable, largely influenced by moist air moving from the Indian Ocean in the east and south east. The erratic nature of this rainfall, therefore, affects agriculture, and consequently household food security, especially in most developing countries in sub-Saharan Africa. Faced by increasing demands for freshwater supplies to sustain the rising population, many African countries are embarking on large engineering projects, such as dam construction, water diversion, and greywater reuse to secure their immediate needs. Amongst the listed project endeavours, greywater reuse provides the most cheaply and lucrative alternative source of water for home gardening amongst the rural poor. Greywater eases pressure on sources of potable water as it can be used for flushing toilets, irrigation of gardens, lawns, shrubs and trees, and dust control. Besides, greywater reuse in agriculture fits well with the concepts of Ecological Sanitation (EcoSan), which seek to prevent pollution and diseases, by managing human urine and faeces as a resource rather than

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waste, through the recovery and recycling of the nutrients (Winblad et al., 2004). It is an established practice in a minority of households, especially in low-income settlements where water availability remains a challenge coupled with financial pressure (Rodda et al., 2010). However, knowledge on greywater reuse in developing countries like South Africa is poorly documented; most literature available is largely from the developed world. The transferability of these methods to the African settings remains sketchy.

For instance, in South Africa, rural communities are largely affected by these challenges (StatsSA Community Survey, 2016). In Fetakgomo municipality alone, a total of 133 106 households are unable to access water, due to illegal water connections, limited communal taps, ageing infrastructure, drought, the topography of the area, and insufficient bulk water supply (Fetakgomo-Tubatse IDP, 2018/19). Most farming is done at a subsistence level and water scarcity, as well as lack of investment on irrigation, is some of the major hindrances (FLM IDP, 2015/16). The aim of the study was to, therefore, assess greywater reuse for household home gardening as an alternative mechanism to improve food security in two rural communities in Limpopo, South Africa. The two communities were chosen based on limited access to running water and the community members still supplement their daily diet with subsistence agricultural produce.

2. Materials and methods

2.1. Study area

Limpopo is the northern most province of South Africa, having international borders with Botswana, Mozambique and Zimbabwe. Fetakgomo Local Municipality is found within Sekhukhune District Municipality which is one of the five district municipalities in the province (Fig. 1). The municipality falls within category B4, regarded as those municipalities which are mainly rural, located in economically depressed areas. The municipality has a spatial coverage of 110 475 ha and is divided into 13 ward s, as well as 4 nodal points namely: Atok, Apel, Mphanama and Strydkraal (Fetakgomo IDP, 2015/16).

The Municipality is dominated by traditional land ownership with a population of 93 814 people that reside in 87 villages with a total of 22 851 households (StatsSA, 2011). Like most rural municipalities in the country, Fetakgomo is characterised by a weak economic base, poor infrastructure, major service backlogs, dispersed human settlements and high poverty levels (Fetakgomo IDP, 2015/16). The study was conducted in two villages in the Fetakgomo Local Municipality, which are Ga-Seroka village consisting of 2 381 households and Ga-Nkwana village with 1 960 households (Fetakgomo IDP, 2015/16). Fetakgomo Local Municipality is characterised with semi-arid conditions with rainfall patterns highly variable. The municipality receives its rainfall in summer (October–March), with an average annual rainfall of 51 mm.

2.2. Sampling techniques

The study adopted a mixed research approach. The approach was chosen because it helps to expand the scope or breadth of research to offset the weaknesses of either of the approaches when used alone (Rossman and Wilson, 1991). The mixed methods procedure involved collecting, analysing, and “mixing” both quantitative and qualitative research methods in a single study to understand a research problem (Creswell, 2012). From a sampling frame of 87 villages in Fetakgomo Local Municipality, with a population of 93 814 people and a total of 22 851 households (StatsSA, 2011), two villages, which are Ga-Nkwana and Ga-Seroka were purposefully selected. Ga-Seroka village is a rural settlement; however, although Ga-Nkwana village is also rural, it has been identified as a potential growth point. Ga-Nkwana village had 1 960 households and a population of 7 429 while Ga-Seroka village had 2 381 households and a population of 6 956 people. The web-based Raosoft sample size calculator was used to obtain a sample of 78

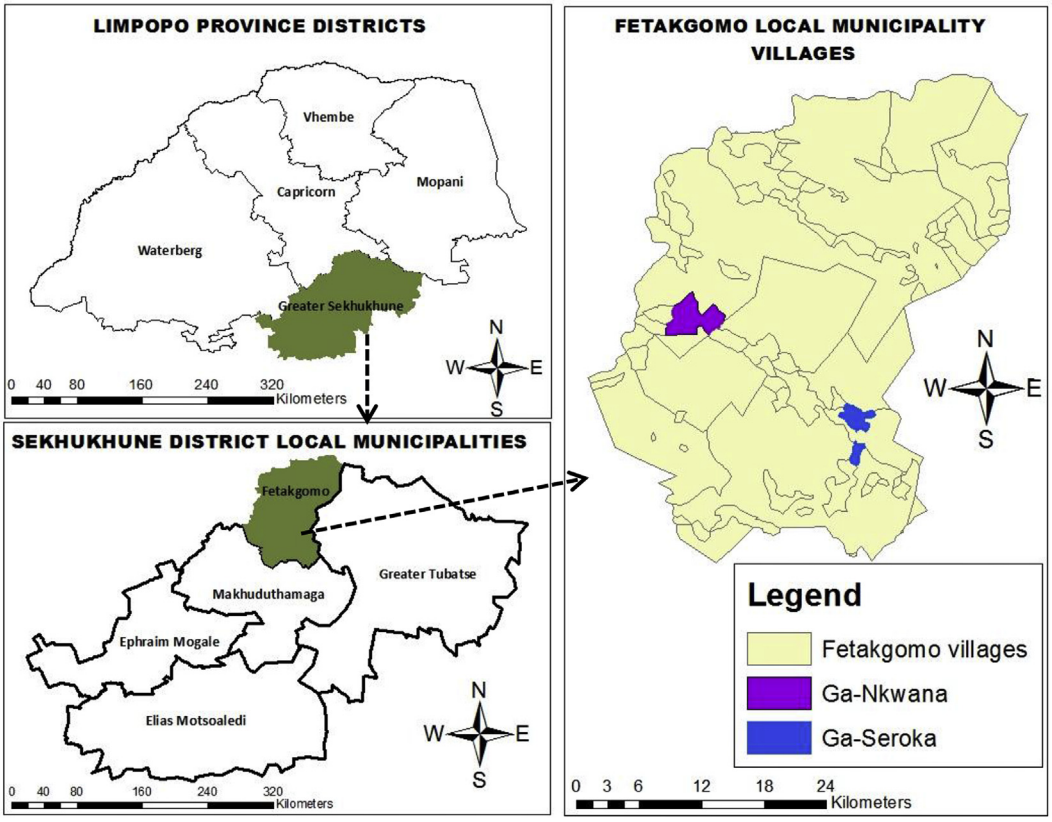

Fig. 1. Location of Fetakgomo Local Municipality in Limpopo province, South Africa.

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households in Ga-Nkwana village and 95 households in Ga-Seroka village, at 95 % confidence level with 10 % and 11 % margin of error for both villages, respectively.

The systematic random sampling method was used (Equation 1) where the K^{th} value represented the sampling interval or the skip. In this case, the K^{th} value was obtained when the total number of households in each village was divided by its sample size. The K^{th} value was 25 for each village. The 1st household was randomly selected and thereafter every 25th household was selected.

$$K^{th} = \frac{N}{n} \quad (1)$$

where: K^{th} is the sampling interval

N is the population size and
n is the sample size

2.3. Data collection

Data was collected by means of 173 self-administered structured questionnaires, which were composed of both open-ended and close-ended questions. Open-ended questions allow the respondents to answer in their own words, thus, they provide richer and more valuable information. The key informants in the study were the Ga-Nkwana and Ga-Seroka villages' royal council committee members, as well as a representative from the Water Service Authority of Fetakgomo Local Municipality. Field observations were conducted during data collection and pictures of how greywater reuse was taken.

2.4. Data analysis

Close-ended responses on the reuse of greywater for home gardening activities were analysed, using a Statistical Package for the Social Sciences (SPSS) software version 23. This was done to obtain the interrelationship of responses to different questions. Responses on the communities' perceptions on the reuse of greywater were analysed by going through all the open-ended responses and manually coding similar or related responses in order to generalise on their responses and develop suggestions and recommendations.

A Chi-Square Test was also further implemented in order to assess whether greywater reuse had the potential to improve household food security in the two villages. Chi-Square was computed as following:

$$\boldsymbol{x}^2 = \boldsymbol{\Sigma}\,\frac{(\boldsymbol{O}-\boldsymbol{E})}{\boldsymbol{E}} \quad (2)$$

where: X^2 is the Chi-Square

Σ is the 'sum of'
O is the frequencies observed
E is the frequencies expected.

For this study, Chi-Square was only used to test the association between question 48 (Have you ever reused greywater in your household) and question 55 (Do you think the reuse of greywater will increase the amount of food you produce) of the questionnaire.

3. Results

3.1. Demographic characteristics

The respondents were rural male and female in the study area. The results show that 55 and 54% of the respondents were males while 45 and 46% being females in Ga-Nkwana and Ga-Seroka villages, respectively (Table 1). Although a high percentage of respondents were males in both villages, most of them reported that their spouses are the ones focusing on the home gardens. Limpopo Province has more females at 53.30% as compared to males at 46.70% (StatsSA, 2011).

Table 1
Demographic characteristics of respondents.

		Ga-Nkwana (%)	Ga-Seroka (%)
Gender	Male	55	54
	Female	45	46
Age (Years)	< 25	5	15
	26–35	15	19
	36–45	43	23
	45+	35	43
Educational levels	None	15	17
	Primary	4	9
	Secondary	26	46
	Tertiary	28	28
Employment level	Employed	51	26
	Unemployed	13	41
	Self-Employed	14	16
	Pensioner	22	17

A large proportion (43%) of respondents in Ga-Nkwana village were within the age range of 36 – 45 years, while in Ga-Seroka village, 43% of the respondents were above 45 years. In Ga-Nkwana village, 26% and 28% of the respondents had secondary and tertiary qualifications, respectively, while 46% and 28% of the respondents in Ga-Seroka village attended secondary and tertiary level. Illiteracy levels were found to be high in Ga-Seroka village, as compared to Ga-Nkwana village (Table 1). A high percentage of respondents (51%) in Ga-Nkwana village were employed whereas 26% of the respondents in Ga-Seroka village were unemployed. It was observed that educated people did not reuse their greywater when compared to uneducated people in both communities. Educated respondents had better-paying jobs as compared to the uneducated resulting in them having sewage systems in their homes whilst the uneducated reused their greywater onsite.

3.2. Greywater reuse

Fifty three percent (53%) of the respondents from Ga-Nkwana village reused greywater in their household while 47% of the remaining respondents did not reuse their greywater. In Ga-Seroka village, 61% of the respondents reused their greywater in their households, while 39% of the respondents did not reuse their greywater. Greywater could be particularly useful for irrigation of subsistence crops, such as African Leafy Vegetables (ALVs), which are consumed across Africa (Van Rensburg et al., 2007); however, its effects on germination and seedling growth in these species are presently unknown (Lubbe et al., 2016). Furthermore, reuse of untreated greywater does contain pathogens, metals, and organic chemicals that might impact soils and/or plants (Finley et al., 2009). Its elevated salinity, pH and boron content can adversely impact soil in the long term (Finley et al., 2009; Al-Hamaiedeh and Bino, 2010; Misra et al., 2010; Rodda et al., 2011). Important parameters to consider for the sustainability of greywater reuse are its pH, electrical conductivity, suspended solids, heavy metals, faecal coliform, Escherichia coli, dissolved oxygen, biological and chemical oxygen demands, total nitrogen and total phosphorus (Dixon et al., 1999a; Birks and Hills, 2007; Erikkson et al., 2002). However, since greywater contains macronutrients, particularly nitrogen and phosphorus, the availability of these nutrients in the right quantities may benefit plant growth. Most importantly, chemical and physical characteristics of greywater are quite variable among households, due to the type of detergents used, type of goods being washed, lifestyle and other practices followed at household levels (Pinto et al., 2010).

3.2.1. Uses of greywater

From the 41 households (53%) in Ga-Nkwana village, 27

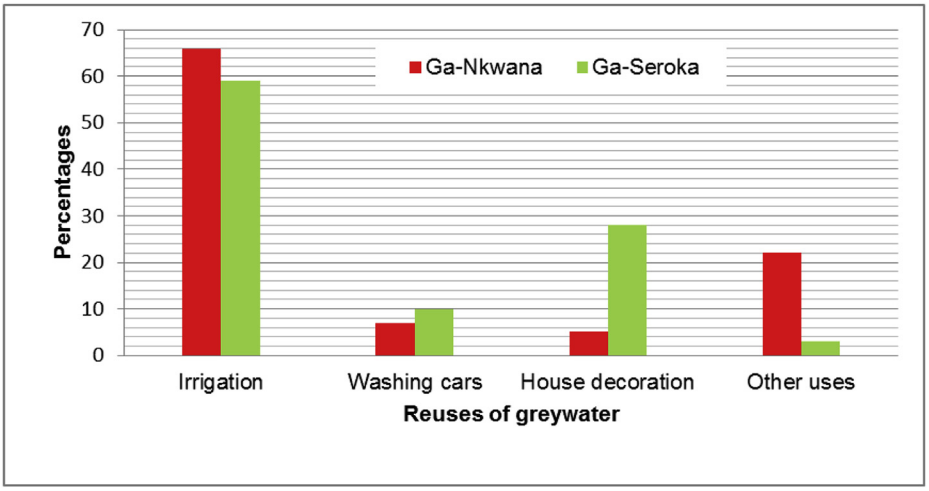

Fig. 2a. Greywater uses in Ga-Nkwana and Ga-Seroka villages.

households (66%) reused their greywater for irrigation, while 3 households (7%) used it to wash cars (Fig. 2a). Two (2) households (i.e. 5%) used their greywater for traditional house decoration whereas 9 households (22%) used their greywater for other uses (Fig. 2a).

Out of the 58 households (61%) in Ga-Seroka village that reused greywater, 34 households (59%) used their greywater for irrigation purposes, while 6 households (10%) used it for washing their cars (Fig. 2a). Households reusing greywater for house decoration were 16 (28%), while 2 households (3%) used their greywater for other uses.

3.2.2. *Types of plants irrigated with greywater*

The respondents in Ga-Nkwana and Ga-Seroka villages used their greywater to irrigate vegetables (A), fruit trees (B), and flowers (C) (Fig. 2b).

Thirty-nine percent (39%) of respondents in Ga-Nkwana village used their greywater to irrigate fruit trees, while 24% of the respondents irrigated their vegetables with greywater. In comparison, 40% of the respondents in Ga-Seroka village reused their greywater to irrigate fruit trees, while 22% of the respondents used their greywater to irrigate vegetables. Twenty percent (20%) of the respondents used their greywater to irrigate their flowers followed by 15% of the respondents who irrigated their crops with greywater. The remaining 2% of the respondents used their greywater for irrigating other non-fruit plants (Fig. 3).

Similarly, twenty percent (20%) of the respondents in Ga-Seroka village irrigated their crops with greywater followed by 16% of the respondents who used it to irrigate flowers. Two percent (2%) of the respondents in Ga-Seroka village used greywater to irrigate other plants (Fig. 3). However, the differences in percentages for irrigating different plants between the two villages are not that much. Respondents from both villages also mentioned that they do not irrigate all their vegetables with greywater, rather only those that are not eaten raw. They further mentioned that although they irrigate with greywater, they also alternate it with freshwater, especially when available because they do not know the effects of greywater on their crops and vegetables, especially when they consume them raw.

3.3. *Perceptions on the reuse of greywater*

The respondents in both villages reused their greywater with caution as they did not know the effects it might have on their produce. Seventeen percent (17%) and 15% of the respondents in Ga-Nkwana

Fig. 2b. Vegetables (A), fruit trees (B), and flowers (C) irrigated with greywater in Ga-Seroka (A&B) and Ga-Nkwana (C) villages.

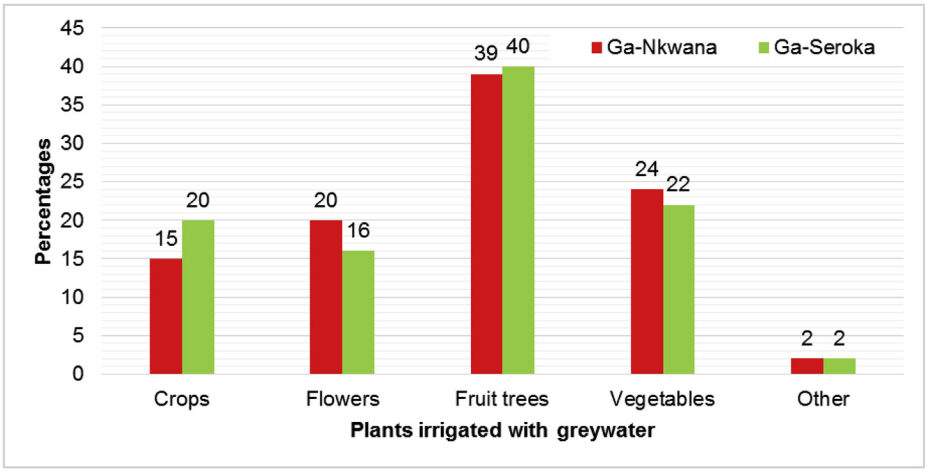

Fig. 3. Plants irrigated with greywater.

and Ga-Seroka villages respectively, indicated that they do not irrigate any plants with greywater from bathtubs because it might have too many detergents that could kill plants, but instead they use water from washing dishes and clothes, especially the water that has been used to rinse the dishes and clothes. Although the respondents used greywater from bathing and doing laundry, they did so with caution. Moreover, the respondents used greywater from these sources mostly for irrigating mature fruit trees as it killed small plants while on the other side it acted as a pesticide and repelled some of the insect-eating plants. Furthermore, kitchen greywater was only used on vegetables that were not to be eaten raw, in order to cook off any chemical that might be found on the harvested vegetables. In addition to irrigating vegetables with kitchen greywater, they alternated greywater irrigation with potable water irrigation when water was available in order to minimise the unknown effects of greywater on the vegetables.

3.4. Potential of greywater reuse to improve household food security

A Pearson Chi-Square test was conducted to assess whether reusing greywater for irrigating gardens can improve the amount of produce made and household food security (Table 2). The Pearson Chi-Square value for the association between greywater reuse for irrigation and produce made was obtained as 52.028[a] with 8 degrees of freedom and a significance probability of less than 0.001 in Ga-Nkwana village whereas it was obtained as 61.772[a] with 2 degrees of freedom and a significant probability of less than 0.001 in Ga-Seroka village, indicating a very highly significant result in both villages.

4. Discussion

Reuse of greywater to supplement freshwater is becoming of great interest specifically in developing countries where the rural communities practice smallholder farming. In this study, it was observed that educated people did not reuse their greywater as much as uneducated people in both communities. Educated respondents had better-paying jobs as compared to the uneducated resulting in them having sewage in their homes whilst the uneducated reused their greywater onsite. Ga-Seroka village is dominated by elderly people who are pensioners and unemployed youth whom in most cases did not further their studies past the secondary education. Many of these youth survive on child social grants and their large household sizes still form a barrier between sufficiency of government safety nets and food security. On the contrary, Ga-Nkwana village is dominated by the working class and most of the respondents have furthered their studies beyond secondary education, which explain the employment percentage of respondents. A high percentage of respondents (61%) in Ga-Seroka village reused their greywater after generation as compared to respondents (53%) in Ga-Nkwana village. Some of the reasons for such results are due to Ga-Seroka village respondents not having a consistent flow of tap water, some communal taps being far and the respondents having to walk long distances to access freshwater. Eventhough respondent in Ga-Nkwana village sometimes struggle to have running water, since they are closer to an area of development, they easily benefit from the development of new services and often receive water via water tankers. Respondents in Ga-Seroka village mentioned buying or fetching water from the river during times when their taps were dry. Most of the rural communities in South Africa are poverty-stricken, lack access to potable water supplies and rely mainly on rain and river water sources for their daily water needs (Dzwairo et al., 2006) and often their river water is shared with their livestock. According to the Department of Provincial and Local Government (DPLG) “municipalities must spend funds on the provision of infrastructure necessary to supply 25 l of potable water per person per day within 200 m of a household and with a minimum flow of 10 l per minute (in the case of communal water points), or 6 000 l of potable water supplied per formal connection per month (in the case of yard or house connections); or to upgrade and build new infrastructure up to a basic level of service in existing formal settlements” (DPLG, 2004–2007).

The reason why most of the respondents (66%) in Ga-Nkwana village reused their greywater for irrigation as compared to 59% of the respondents in Ga-Seroka village was due to the fact that Ga-Nkwana village did not struggle as much as Ga-Seroka village with regard to access to water. This also means that the quantity of greywater generated was bound to be more in Ga-Nkwana village. Home gardens have been a source of food for many rural households and variations in rainfall patterns is affecting livelihoods of many, hence the shift to greywater reuse. Madungwe and Sakuringwa (2007), reported that the uses of greywater in crop irrigation allow households the opportunity to

Table 2
Pearson Chi-Square test on greywater reuse.

Variables	Village	
	Ga-Nkwana	Ga-Seroka
	n (%)	
Reuse of greywater	41 (53%)	58 (61%)
Increase in the amount of food produced	24 (31%)	24 (25%)
P value	0.000	0.000

n: Number of respondents, %: Percentage of households, P value: 0.05, Chi-Square value: 52.028[a] (Ga-Nkwana) and 61.772[a] (Ga-Seroka) and Degree of Freedom: 8 (Ga-Nkwana) and 2 (Ga-Seroka).

grow crops during the times when water is not readily available, leading to less water stress and increased food security. Besides greywater has nutrients which are good for plant growth (Friedler et al., 2006; Godfrey et al., 2009; Salukazana et al., 2004). Fruit trees (specifically grown up trees) have been irrigated more with greywater in both villages and this is due to greywater killing small plants. Irrigation with greywater has reduced the amount of crop-eating pests, due to its smell and detergents content. Greywater is a widely-used method of conserving freshwater, especially when climate change is affecting water availability. Manufacturers of detergents that are normally used in the households are already producing environmentally friendly detergents making it easier to reuse greywater onsite without any form of treatment (Deshmukh et al., 2014). In rural households, people directly reuse greywater to irrigate vegetable gardens in order to supplement their food with household garden produce to sustain their livelihood (Rodda et al., 2011).

Fetakgomo Local Municipality does not have enough capacity to act as a Water Service Authority within its area of jurisdiction, therefore, the water service authorities and providers of the municipality are in the Sekhukhune District Municipality. Elevation acts as a barrier for water supply in both villages as some of the households are on top of hills or mountains. Water supply in Ga-Nkwana village does not have enough power to move uphill leaving those households in elevated areas without water from their home taps. On the other hand, Ga-Seroka village is a mountainous area and infrastructure that distributes bulk water from Lepelle Northern Water Scheme does not reach the area due to elevation. Furthermore, Fetakgomo Local Municipality does not have any greywater treatment system although other local municipalities, such as Ephraim Mogale and Greater Tubatse do have such treatment systems.

4.1. Implications to policy and rural livelihoods improvement

The Sustainable Development Goals (SDGs), specifically objective number 2 of the United Nations Development Plan (UNDP), aims to end hunger, achieve food security and improve nutrition and promote sustainable agriculture (FAO, 2010; FAO, 2013). These goals are further supported by chapter 6 of the National Development Plan (NDP)-2030 which aims at achieving an integrated and inclusive rural economy through the improvement of livelihoods. The plan furthermore highlights that better integration of the country's rural areas can be achieved through successful job creating and poverty alleviating projects. Irrigated agriculture, which can be supplemented by dry land production with an emphasis on small scale farming, which is seen as the driving force in combating poverty in rural areas in future. The findings of this study are important for policy development and are inline with the mandate of SDGs and NDP when coming to poverty alleviation. The results are also important for the formulation of greywater reuse guidelines especially for irrigation of food crops in South Africa. Through selling of surplus vegetables, the households will have more money for basic needs and enough healthy food to supplement the food. This will also help bridge the gap of men being the common providers at home while also creating jobs. The results of this study are also important for female-headed households, as they are the most vulnerable to poverty. The availability of/continuous production of vegetables for households all year round will mean enough healthy food to supplement market- bought food through the reuse of greywater, which is always available in abundance given the source of generation

5. Conclusions

The reuse of greywater for home gardening was practised more in Ga-Seroka village than in Ga-Nkwana village. The perceptions on greywater reuse in this study were different as Ga-Seroka village respondents preferred to reuse greywater more as compared to Ga-Nkwana village respondents. This is highly influenced by the lack of running water in Ga-Seroka village as compared to Ga-Nkwana village which makes greywater reuse of potential beneficial use for irrigation of home gardens and thus improving food security. It can be concluded that irrigating home gardens with greywater can improve the amount of produce made and thus improve household food security through availability. The fact that some of the plants irrigated with greywater did not die and the greywater killed and repelled some of the insects-eating plants could be an added advantage of reusing greywater.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pce.2019.02.009.

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